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DIRECTED MODIFICATION AND SELECTION OF MICROORGANISMS

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One of the most important problems of modern microbiology is the directed modification and selection of microorganisms. A scientific meeting held in Moscow under the auspices of the Academy of Sciences USSR a short time ago was devoted to progress achieved in this field during recent years in the subdivisions of general, medical, technical, and agricultural microbiology. At this meeting a comparative evaluation of various methods for obtaining practically useful forms of microorganisms was given. These methods comprise search for practically valuable, naturally occurring strains, their selection in the course of production, and experimental modification of microorganisms in a direction sought by the experimenter. In the USSR the third method receives the greatest amount of attention.

Modifications of the conditions under which microorganisms exist bring about changes in the type of metabolism and, consequently, changes in heredity. The truth of this postulate is confirmed by many data from the fields of medical and technical microbiology.

To achieve directed modification of a microorganism, the investigators may use methods which have been tested and proved effective in practice. The desired aim can be achieved by repeated reseedings of the culture under fixed conditions of existence. Alternatively, directed modification can be brought about by means of vegetative hybridization with the aid of other cultures of microorganisms, or else new properties can be developed, using substances isolated from the cells of other microbes. This produces modifications adapting microorganisms to new conditions of existence. Sexual hybridization is possible only in a limited number of cases, e.g., yeasts.

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At present the most serious difficulties in work of this type are encountered in connection with attempts to reinforce certain biochemical properties of microorganisms and to create forms which exhibit new biochemical characteristics. For that reason, particular attention should be paid to research dealing with the regulation of metabolism in such a manner that methods of directed modification affecting fermentation activity, rate of propagation and growth, immunogenic properties, formation of valuable products by bacteria, etc., become feasible.

In large-scale work on the selection of microorganisms, when the investigator deals with a very great number of cultures, the possibility of selecting or discarding cultures on the basis of morphological characteristics connected with certain physiological, biochemical, or antigenic properties becomes of great significance. For that reason, research on relationships involved in such selection is very useful from this standpoint.

I. Ye. Glushchenko, M. N. Meysel', et al., touched upon the application of strongly acting chemical and physical factors in attempts to obtain cultures having modified properties. This is the method of choice as far as adherents of the Weismann-Morgan school are concerned. Independently of the nature of the object (i.e., whether it be a microorganism, a higher plant, or an animal), this method is applied by them for any number of purposes. T. D. Lysenko pointed out that this method cannot lead to useful results and is not an effective aid in planned selection. In the case of microorganisms, degeneration and lowered vitality result from the application of a method of this type. However, some forms of microorganisms which develop in consequence of this treatment may be of practical use as indicator cultures for the determination of enzymes, vitamins, amino-acids, and other substances.

In recent years Lysenko and his collaborators collected a large amount of data confirming the transmutation of one species of plant into another and on the basis of results obtained by them developed a theory of biological species and of the formation of species. S. N. Muromtsev cited data on microorganisms which prove that transformation of individuals of one species into individuals of another species takes place [under natural conditions existing] at the present time.

Working independently of each other on the same microorganisms and often using different methods in their work, V. D. Timakov, G. P. Kalina, and F. T. Grinbaum arrived at essentially the same results. V. D. Timakov and his group demonstrated that after prolonged breeding of B. coli on synthetic media containing as the sole source of nitrogen bacterial bodies of another species of microorganism and their complete antigens, B. coli acquire all properties of the culture on the products of which they were grown. For instance, if they were grown on products of paratyphoid bacilli of the Breslau type, they acquired all antigenic, biochemical, and serological characteristics possessed by the causative factor of paratyphoid B. The transformation of bacteria of one species into those of another takes place abruptly, and the newly acquired properties retain their stability during a long period of cultivation on customary nutritive media or a period of passing through an animal organism.

Professor Kalina assumes that the mutual relationship of different bacteria in any given association is determined by metabolic conditions. At a certain stage of development, some species occupy a dominant position, while others are subordinate and must adapt their type of metabolism to that of the form which predominates in the association. As a result of changes in metabolism, the antigenic characteristics and pathogenicity of the bacterial form in question change. The processes taking place in bacterial associations are essentially similar to those occurring in the vegetative hybridization of higher plants. Vegetative hybridization of microorganisms occurs widely in nature, e.g., in the intestines of humans and animals. It explains the fact that B. coli contained in the intestines of typhoid or dysentery patients change their antigenic

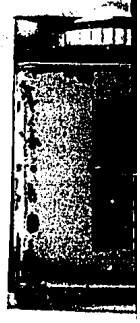
characteristics and acquire the capacity of being agglutinated by sera of the causative factor of typhoid or dysentery. While acquiring properties of typhoid or dysentery bacilli, B. coli lose their own typical characteristics, including the antagonistic reaction towards dysentery bacilli which they exhibited originally. In other words, there is unmistakably a transformation of one species into another in this case. Kalina is of the opinion that such transformations of B. coli play a definite role in the pathogenesis of infectious diseases and must be taken into account in carrying out antiepidemic measures.

The work of Professor Grinbaum and his group dealt with changes which pathogenic bacteria undergo on being exposed to conditions that differ sharply from those under which they exist normally. In this work, particular attention was paid to the effect of an immune organism or unsusceptible organism after infection. According to Grinbaum, the infected organism during the early stage of the disease yields typical forms of the microorganism infecting it. In the period of convalescence, atypical forms which had been modified by the organism are yielded. Particularly pronounced changes occur when pathogenic bacteria are transferred from the human organism into the surrounding medium. Grinbaum et al. established that typhoid bacilli, on being transferred into water and remaining there, sharply change their antigenic and biochemical properties. Typhoid bacilli existing in water may change into a filterable form. In general, these bacilli become modified to such an extent in water that it is impossible to establish their presence by ordinary tests. One must take account of this condition in medical and sanitary work.

While Timakov and Kalina demonstrated the transmissibility of B. coli into pathogenic typhoid, paratyphoid, and dysentery forms, and Grinbaum showed that pathogenic forms belonging to the intestinal-typhoid group can be transformed into B. coli or other forms that differ radically from the initial microorganism, epidemiological, immunological, and practical aspects of the transformation of bacteria along these lines have been neglected. More attention should be paid to the breeding of new forms usable for the production of live vaccines, development of microbiological diagnostic methods under consideration of the modifying effect of the microorganism on the causative factor of the disease, and identification of bacteria in the outer medium by methods which take due account of their modifiability. In developing useful cultures of bacteria, one must not only obtain forms having the desired properties, but also achieve conditions under which these properties remain stable and inheritable. Work done by N. D. Yerusalimskiy was devoted to this question.

On being kept under laboratory conditions, many cultures degenerate. This does not happen spontaneously because an unavoidable phase of the life cycle sets in, as assumed by the theory of cyclogeny and dissociation. Degeneration of the culture can be prevented and loss of useful properties avoided by controlling external conditions in an adequate manner. When normal conditions are changed, a certain percentage of unadaptable individuals perishes, but the rest survive and change their metabolism, which brings about changed heredity. Yerusalimskiy proposes to establish experimentally, by means of physiological analysis, under what specific conditions the desired properties can be developed, fixed, and strengthened, and then to carry out cultivation under these conditions. In doing this work, the changeability of physiological properties and requirements of every culture depending on age must be considered.

During the meeting, very interesting information on the directed modification and selection of yeasts and viruses was presented. Development of new strains of fungi exhibiting an increased activity of amylolytic enzymes was also reported.



O. B. Lepeshinskaya pointed out various shortcomings of current work on directed modification, stating that insufficient attention is being paid to the study of metabolism of microorganisms, the investigation of filterable forms, and the role which noncellular matter plays in phenomena of directed modification and the formation of new species of microorganisms.

I. Ye. Glushchenko presented a report criticizing the Weismann-Morgan schools and deploring the fact that individual papers presented at the meeting were not subjected to adequate criticism and evaluation. A resolution calling upon USSR microbiologists to criticize more effectively in print foreign reactionary genetic theories e.g., theory of biochemical genetics, was passed.

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